NIGHT VISION CAMERA SYSTEM FOR INTRUDER DETECTION IN INDOOR AND OUTDOOR ENVIRONMENT

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ABSTRACT

This project presents the detection of intruder existence by using a night vision camera system in indoor and outdoor environment. The entire project is done by using image processing techniques via OpenCV which run on Linux environment. The challenge of this project focuses on the detection ability of intruder by using a webcam at a fixed distance in low light condition. The histogram is generated to show the tonal variations and distribution of every frame of the images. Intruders can be detected by detecting the changes occur in the foreground image and the changes of histogram from the real-time video streaming through the webcam.

ABSTRAK

Projek ini membentangkan mengesan kewujudan penceroboh dengan menggunakan sistem penglihatan malam kamera dalam persekitaran dalaman dan luaran. Keseluruhan projek ini dilakukan dengan menggunakan teknik pemprosesan imej melalui OpenCV yang berfungsi dalam persekitaran Linux. Cabaran projek ini memberi tumpuan kepada keupayaan pengesanan daripada penceroboh dengan menggunakan kamera web pada jarak yang tetap dalam keadaan cahaya rendah. Histogram ini dijana untuk menunjukkan variasi yang mempergunakan gaya suara dan pengedaran setiap bingkai imej. Penceroboh boleh dikesan dengan mengesan perubahan berlaku dalam imej latar depan dan perubahan histogram daripada video masa sebenar streaming melalui webcam.

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LIST OF ABBREVIATIONS

OpenCV	Open Source Computer Vision
CCTV	Closed-circuit television
PC	Personal computer
USB	Universal Serial Bus
RAM	Random Access Memory
LED	Light-emitting diode

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

This chapter is to have a brief overview on the project background, problem statement, objectives of this project and scopes of the project.

1.2 PROJECT BACKGROUND

Over the years of continued evolution in our world, house breaking at both residential area and industrial area have been a serious problem in every each of the corners in the world. This problem had brought a creation of device named security system to detect intruders for either private housing areas or industrial areas. There are more and more users are trying to apply security system at their own private estate including the most advanced night vision infrared camera for intruder detection. There are quite a lot of security monitoring devices in the market such as CCTV camera, and fingerprint access identification system and face recognition system, but most of the house breaking cases happened in the night time and we are not able to see anything in the dark with our bare eyes and we are not able to give any respond right after the intruders broke in. This had caused a lot of losses to the properties due to poor detection of intruders in the night time. To avoid this kind of problems, we install night vision camera system in our own properties so that if there is an intruder appear or break in, we are able to detect their existence in advance to recognise them and capture their looks in

the dark. In this project, we are going to detect the existence of intruders through the webcam connected to PC which mounted at static position in the low light condition. The webcam used is a normal USB webcam which can be easily obtained. The camera allows us to capture image in the dark or low light condition and finally the image or video captured can be used for further analysis from time to time.

1.3 PROBLEM STATEMENT

Everyone of us has our own properties such as cars, land and houses. As we know, we are just not able to protect and monitor our properties all the time. Sometimes, we are not around in our house or when we went for travelling, nobody is staying in the house for few days. This has brought the chances for intruders to break into our house especially in the night time. Poor detection of intruders inside and outside of building in the night time has caused a great loss of the properties and also life-threatening to the human. Somehow, the cost of one full set of CCTV system is considered as high cost due to the combination of devices cost and installation cost while this is the price that not everyone can afford to own it.

1.4 PROJECT OBJECTIVES

1) To investigate the intruder detection system with a USB camera as night vision camera that can be used in indoor and outdoor of buildings.
2) To analyse the light intensity required to capture a picture by the USB camera to detect intruders.
3) To determine the distance required to capture the shadow of intruders in the dark environment.

1.5 PROJECT SCOPE

1) Interfacing the USB night vision camera with the program.
2) Analysing the quantity of light required to detect intruders.
3) Conduct tests on the ground by using the USB camera to determine the possible distance between intruders and the camera to capture the image of the intruders.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter will briefly explain about the working principle of a night vision camera, system design and software approach for this project. All the information and sources regarding night vision camera are summarized from the internet sources, articles, journals, and related academic text book. Literature review gives a help in providing important theories and information and essential concept regarding previous research which related to projects of night vision camera. These information and theories are considered important in order to proceed to analysis and further study about the topic.

2.2 NIGHT VISION

Night vision is a technology that allowing one to see more clearly in the dark environment. Human have poor night vision compared to many other animals especially for those animals which hunt their prey in the dark environment. The reason why those animals can see in the dark is that they have a layer of tissue called as tapetum lucidum in their eyes. The tapetum lucidum tissues allow the visible light to reflect back along the light path through the retina in their eyes, yet maintaining the sharpness and contrast of the image on their retina, providing higher light intensity to be received by the photoreceptors and transfer the nerve signal to their brain, result them to see more clearly in the dark environments. That is why those animals have glowing eyes when the light flash into their eyes during the night time, creating creepy and scary looks.

Those animals have the ability to see in the dark where human does not have. That is because human can only see the world when the electromagnetic radiation with wavelength in the range of 380 nm and 750 nm where the frequency is between 400 THz to 789 THz, normally called as visible light. The visible spectrum is provided as below (figure and table taken from Wikipedia):

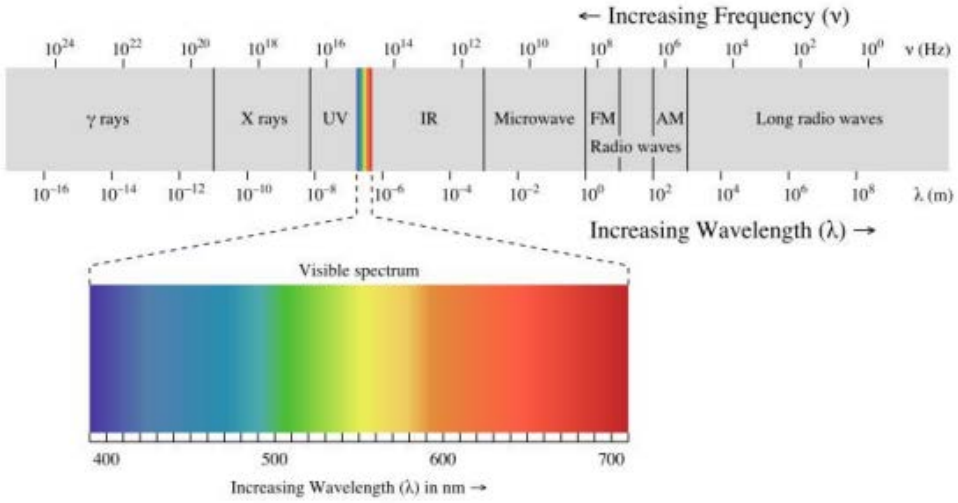

Figure 2.1: Electromagnetic Spectrum with details.

Color	Frequency	Wavelength
violet	668–789 THz	380–450 nm
blue	606–668 THz	450–495 nm
green	526–606 THz	495–570 nm
yellow	508–526 THz	570–590 nm
orange	484–508 THz	590–620 nm
red	400–484 THz	620–750 nm

Figure 2.2: Frequency and Wavelength of Visible Light.

There are a lot of applications of night vision, including military, security, surveillance, wildlife observations and navigation. Military force use night vision goggles to see and locate their enemy in order to complete their mission in the dark environment while a lot of buildings are mounted with night vision devices to monitor the surroundings and for surveillance purpose. On the other hand, many ecologist use night vision technology to observe the ecological changes and wildlife animals in the dark.

2.3 NIGHT VISION DEVICES

Figure 2.3: Example of night vision devices.

The night vision technologies have been widely used in surveillance devices especially night time pedestrian detection system and intruder detection system. When it comes to this topic, there are two approaches, which are image intensification, also known as light amplification and thermal imaging.

2.4 LIGHT AMPLIFICATION

2.4.1 Working principle of Light Amplification

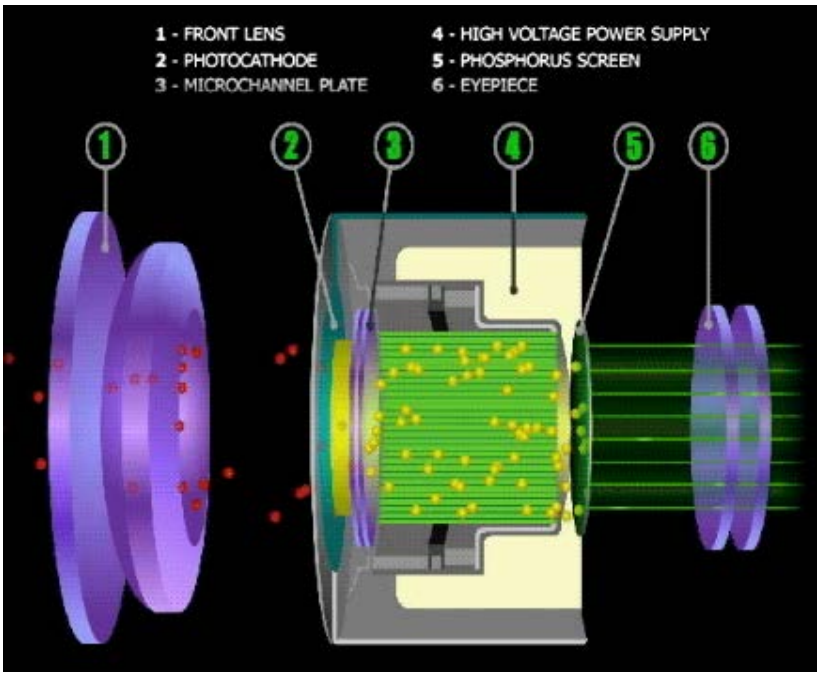

Figure 2.4: Working principle of Light Amplification.

Most of the night vision devices use light amplification technology to achieve better vision in the dark environment is because light amplification is less expensive than thermal imaging. For light amplification, it can be done by collecting and gathering tiny of existing light such as moonlight, starlight and low portion of infrared light that exist in surrounding area through the front lens, also known as objective lens. Then, the light goes into the image-intensifier tube, also known as photocathode tube, to convert the light energy (photons), into electrical energy which called as electrons. When the electrons are passing through the tube, much of electrons are released from atoms and amplified thousand times to much greater of the original number through the microchannel plate and accelerated by an electrical voltage to increase their speed in the tube. Then, the electrons are projected to a screen coated with phosphorus, in order to let the amplified electrons to stay in same alignment and change the electrons back into original photon which provides a perfect image that can be seen through the eyepiece. The electrons cause the phosphorus to reach excited state which produces an amazing

green glowing output image and impressive nighttime view even in a very dark environment.

Figure 2.5: Example of output image after light amplification.

2.4.2 The advantages and disadvantages of Light Amplification

Advantages	**Disadvantages**
Excellent sensitivity towards low light level.	It requires at least a little bit of light source and it is not useful in no light condition.
Enhanced visible image into best quality for recognition and identification purposed.	Weak performance during daytime compared to daylight-only method.
Lower cost required.	Damage might occur when observing at bright sources under low light environment.
High resolution.	

Table 2.1: Advantages and disadvantages of light amplification

2.5 THERMAL IMAGING

2.5.1 Characteristic of electromagnetic spectrum

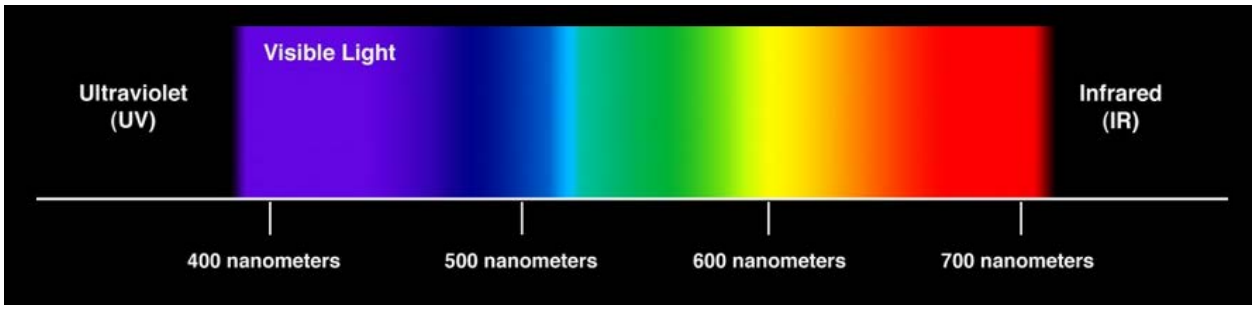

Figure 2.6: Electromagnetic spectrum.

All the natural or artificial objects in this world emit infrared as a function of heat energy. In order to understand how thermal imaging works, there is something which is more important to know first, that is light spectrum. A light wave contains some amount of energy which refers to light energy. The amount of the energy exist in the light wave are depends on the wavelength of the light wave. Shorter wavelength will consist of higher energy. From **Figure 2.2**, we know that in visible light, violet has the shortest wavelength which means that it has the highest energy amount in it while red has the longest wavelength which consist the least amount of energy. Human eyes are capable to see the objects in visible light only when objects emit the visible light at very high temperature. All the objects emit infrared energy at ordinary temperature. If the object is hotter, means that it emits higher infrared energy. Infrared has longer wavelength than visible light and human eyes cannot see it but thermal imaging devices can. Infrared can be catagorised into three:

1) Near Infrared (NIR) - Closest to visible light, NIR has a range of wavelengths from 0.7 to 1.3 microns.
2) Mid Infrared (Mid IR) -Mid IR has a range of wavelengths from 1.3 to 3 microns.
3) Thermal Infrared (Thermal IR) – Has the largest range of the infrared spectrum, it has a range of wavelengths from 3 microns to more than 30 microns.

Both near-IR and mid-IR are used by a variety of electronic devices, including remote controls and the difference between Thermal IR and the other two IR is infrared light is emitted by an object but not reflected off.

2.5.2 Working principle of Thermal Imaging

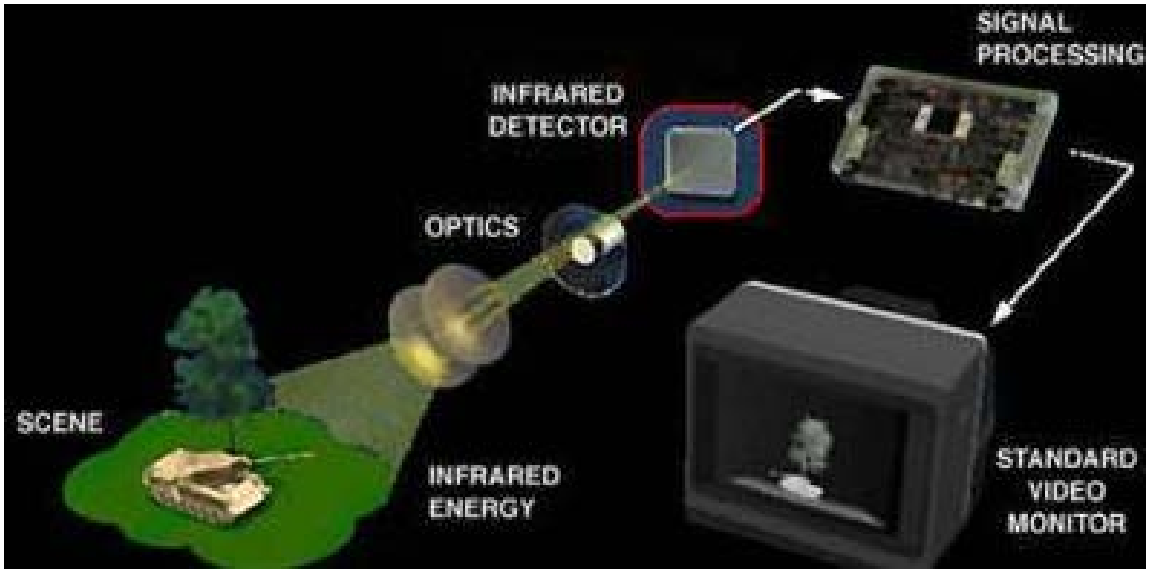

Figure 2.7: Working principle of Thermal Imaging.

Different from light amplification method, thermal imaging do not require any existing light at surrounding at all. It means that it is totally light level independent and also it can penetrate smokes, haze, and fog when focusing on the objects. A special optic lens on the infrared detector is used to focus the infrared light emitted by all of the objects in the scene. The focused light is then scanned by a phased array of infrared-detector elements and a very detailed and informative representing temperature information will be created and it is called as thermogram. Then, the thermogram will be translated into electrical impulses and send to image processing unit to produce output image that can be viewed on displaying unit of a thermal imaging device or other electronic display. The image produced by thermal imaging devices are normally appears in black and white colours, depending on the intensity of the infrared emission by the objects, where black colour objects are cold in temperature while white colour objects are in hot temperature. If there is a temperature difference between two objects that the

thermal imaging devices detected in a scene, then a contrast of black and white image will be shown on the display clearly that the human eyes cannot detect when the surrounding has no light at all.

Figure 2.8: Example of output image using Thermal Imaging.

Figure 2.9: Comparison between visible light image and Thermal Imaging output image.

2.5.3 The advantages and disadvantages of Thermal Imaging

Advantages	Disadvantages
High sensitivity towards thermal responses.	Lower resolution compared to light amplification method.
Easy to detect people and vehicles.	Devices are heavy and bulky.
Do not being affected by any bright light sources.	Expensive to purchase and to operate for Cooled-detector Thermal Imaging Cameras
High contrast in dark environment	Cannot be used for multispectral or high-speed infrared applications for Uncooled-detector Thermal Imaging Cameras

Table 2.2: Advantages and disadvantages of thermal imaging

2.6 SYSTEM DESIGN PROBLEM

The fundamental problem of night vision camera system for intruder detection is important and crucial and should be understood and identified. This is to ensure that the night vision camera system can achieve optimum performance in all aspects continuously. Design problem can be solved by following steps:

1) Determine the basic characteristics and specifications of the night vision camera used.
2) Determine how much of light intensity required to monitor the condition at indoor and outdoor environment.
3) Identify the distance required to capture the shadow of intruders in the dark environment.
4) Decide the location to mount the night vision camera to monitor the indoor and outdoor environment.
5) Identify the design and maintenance cost required.
6) Investigate the flexibility and durability of the night vision camera, whether the night vision camera system can sustain in such hot weather in Malaysia.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

The aim of this chapter is to presents the fundamental frameworks of method which used to investigate the light intensity needed to capture a picture by night vision camera to detect intruders. This chapter will also outline how the project will be conducted and how it will develop according to the methods available.

3.2 FLOWCHART

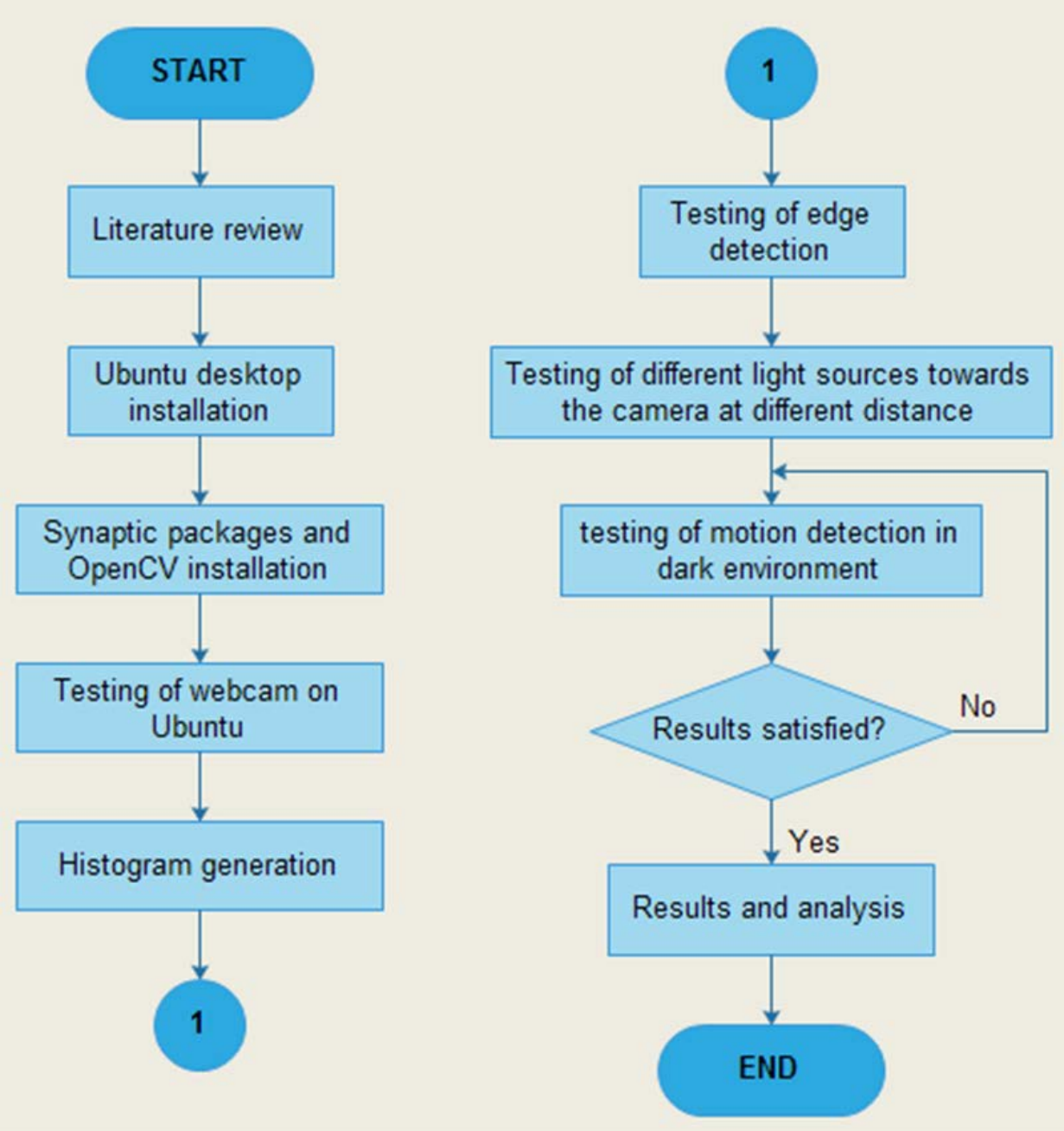

Figure 3.1: Project flowchart